INDOOR AIR QUALITY ASSESSMENT

Massachusetts Department of Mental Health
Milot House
Tewksbury Hospital Campus
Tewksbury, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Stephen Napolitano, Investigations Manager, Massachusetts Department of Mental Health (DMH), the Massachusetts Department of Public Health's (MDPH) Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the Milot House located on the Tewksbury Hospital Campus, Tewksbury, Massachusetts. This request for assistance was communicated through Lana Jerome, Human Resources Director, Office of Health, Executive Office of Health and Human Resources (EOHHS). The assessment was prompted by occupant concerns about mold growth and associated odors within the building. On May 2, 2007, a visit to conduct an indoor air quality assessment at the Milot House was made by Cory Holmes, an Environmental Analyst in BEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. During the assessment, Mr. Holmes was accompanied by Paul Lamothe, Director of Core Services, DMH.

The Milot House is a two-story red brick building constructed in the early 1900s as a residence. The building consists primarily of office space for DMH investigative staff; the basement is unfinished and used for storage of files. Windows are openable throughout the building.

As mentioned previously, the request was prompted by mold concerns. Mr. Napolitano and Mr. Lamothe reported that prior to the MDPH assessment a water-damaged carpet had been removed from the vicinity of the rear entrance of the building. Removal of the carpet reportedly reduced the musty/mold-odors.

Methods

MDPH staff performed a visual inspection of building materials for water damage and mold growth. Moisture content of porous building materials (e.g., plaster, gypsum wallboard

(GW), wood) was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe. Tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The Milot House has a staff population of 11. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, which is generally indicative of adequate air exchange. It is important to note, however, that the Milot House does not have any means of mechanical ventilation, but uses windows to introduce fresh air. Cooling is provided by window-mounted air-conditioning (AC) units.

The Massachusetts Building Code requires that each room in an office have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature readings in occupied areas during the assessment were measured in a range of 68^{o} F to 78^{o} F, which were within or close to the lower end of the MDPH comfort guidelines. The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is often difficult in an older building without a mechanical ventilation system.

The relative humidity measured in the building ranged from 30 to 50 percent, which in most areas was below the MDPH recommended comfort range the day of the assessment. The MDPH recommends that indoor relative humidity be maintained in a comfort range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of moisture is necessary. Should building materials become wet, identifying and eliminating water moistened building materials is necessary to control mold growth. Building materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth. As previously mentioned, carpeting in the vicinity of the rear door was removed (Picture 1). BEH staff examined this door and found that the wood was severely water damaged and colonized with mold (on the exterior) at the time of the assessment (Picture 2).

In an effort to ascertain moisture content of building materials, moisture readings were taken in materials that clearly showed evidence of water damage as well as other materials most likely impacted by water penetration. The Delmhorst probe used to measure moisture content is equipped with three lights that function as visual aids indicating moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level; those that activate the yellow light indicate borderline conditions; and those that activate the red light indicate elevated moisture content. The exterior rear door was found to have elevated moisture content (Picture 3/Table 1). Moisture content of materials is a real-time measurement of the conditions present in the building at the time of the assessment.

The source of moisture is likely rainwater accumulating against the building exterior, due to a lack of gutter/downspout system along the roof edge (Picture 4). Wooden eaves along the roof edge, especially at the cornice, showed signs of damage and swelling. Water splashing along the edge of the building moistens the base of exterior walls, creating a characteristic staining. Growth of moss on exterior brickwork is also an indication of chronic moisture exposure from rainwater (Picture 5). Moss growth holds moisture against brickwork, which can further damage the building exterior. North-facing corners and walls of this building are particularly vulnerable to prolonged moisture exposure, since the brick is not dried out by exposure to direct sunlight. During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork. Over time, chronic moisture exposure has resulted in damage to the building's exterior (Pictures 6 and 7).

As discussed, the wooden eaves of the building are damaged due a lack of a gutter/downspout system. As depicted in Picture 4, the cornice shows extreme signs of deterioration. Interior building materials in a corresponding second floor area also showed signs of water damage (Picture 8).

Several additional conditions identified along the building's exterior may contribute to water penetration into the building. These include the following:

- Clinging plants on exterior walls (Pictures 9 and 10). Clinging plants can cause water damage to brickwork through insertion of tendrils into brick and mortar. Water can penetrate into the brick along the tendrils. Water trapped in brick can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in wall damage.
- Missing/damaged mortar and cracks in exterior brick/stone (Pictures 11 through 13).
- Rotted wood and spaces around flashing and in masonry around windows (Pictures 14 through 16).
- An abandoned dryer exhaust vent (Picture 17).

- Damage to an exterior door/wall resulting in severe water damage to the side entrance stairwell (Pictures 18 and 19). Note, this entrance is sealed and the stairwell is not used by DMH staff.
- Clogged exterior drain and damaged wooden door to basement (Pictures 20 and 21).

Repeated water penetration can result in the chronic wetting of building materials and potentially lead to microbial growth. In addition, these breaches in the building's exterior may provide a means of egress for pests/rodents into the building.

It is also worth noting that a leaking sink and cardboard boxes stored directly on the cement floor were observed in the basement. Moistened porous materials can provide a source for mold growth (Pictures 22 and 23).

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If porous materials are not dried within this time frame, mold growth may occur.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide can produce immediate, acute health effects upon exposure. To determine whether combustion products were present, BEH staff obtained measurements for carbon monoxide.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations during the assessment were measured at 1 ppm (Table 1). Carbon monoxide levels measured throughout the building ranged from 1 to 2 ppm (Table 1). At no time was carbon monoxide detected above the NAAQS of 9 ppm for carbon monoxide, however a potential point source of combustion products was identified in the basement.

While in the basement, Mr. Holmes and Mr. Lamothe observed a furnace operating (Picture 24). Upon closer inspection, it appeared that the furnace was missing its cover and venting *into* the basement (Picture 25). Not only can the furnace serve as a point source of combustion products into the basement (e.g., carbon monoxide), but it can also pressurize the basement, forcing odors and particulates into occupied areas of the building.

Lastly, the interiors of window-mounted AC units and their filters had accumulated dust. Dust particles can also be aerosolized when ACs are activated, which can be irritating to the eyes, nose and respiratory tract.

Conclusions/Recommendations

The general building conditions, maintenance and work hygiene practices at the Milot House, if considered individually, present conditions that can degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required. This approach consists of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Replace damaged exterior rear door.
2. Have furnace inspected to ensure proper installation/operation. Make repairs as needed.

3. Clean/change filters for AC units as per the manufacturer's instructions or more frequently if needed. Prior to activation, vacuum interior of units to prevent the aerosolization of dirt, dust and particulates.
4. Refrain from storing porous materials directly on basement floor. Inspect and discard any water damaged/mold colonized materials. Disinfect any areas of microbial growth with a mild detergent or antimicrobial, wipe clean surfaces with soap and water after disinfection.
5. Unclog drain near basement doors. Inspect periodically for proper drainage.
6. Remove plant growths against the exterior wall/foundation of the building to prevent water penetration.
7. Clean exterior walls of moss and debris.
8. Refer to "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency (US EPA, 2001) for information concerning mold and mold remediation. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.
9. Refer to resource manuals and other related indoor air quality documents for additional building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air.

The following **long-term measures** should be considered:

1. Consider consulting with an architect, masonry firm or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through exterior walls. This measure should include a full building envelope evaluation.
2. Install gutters and downspouts to direct water away from the building.

3. Repair/replace damaged exterior wooden doors and moldings.

4. Repair/replace damaged interior of materials in side entrance stairwell.

5. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames.

References

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US EPA. 2001. “Mold Remediation in Schools and Commercial Buildings”. Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html

US EPA. 2006. National Ambient Air Quality Standards (NAAQS). US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

Picture 1

Area of odors near exterior rear door, where carpeting was removed

Picture 2

Heavily damaged wooden exterior rear door, dark stains indicate mold growth

Picture 3

Elevated moisture measurement of exterior rear door

Picture 4

Damaged/rotted wooden cornice at rear of building directly above door in Pictures 1-3, note the lack of a gutter/downspout system

Picture 5

Moss growth due to chronic water exposure near rear exterior door

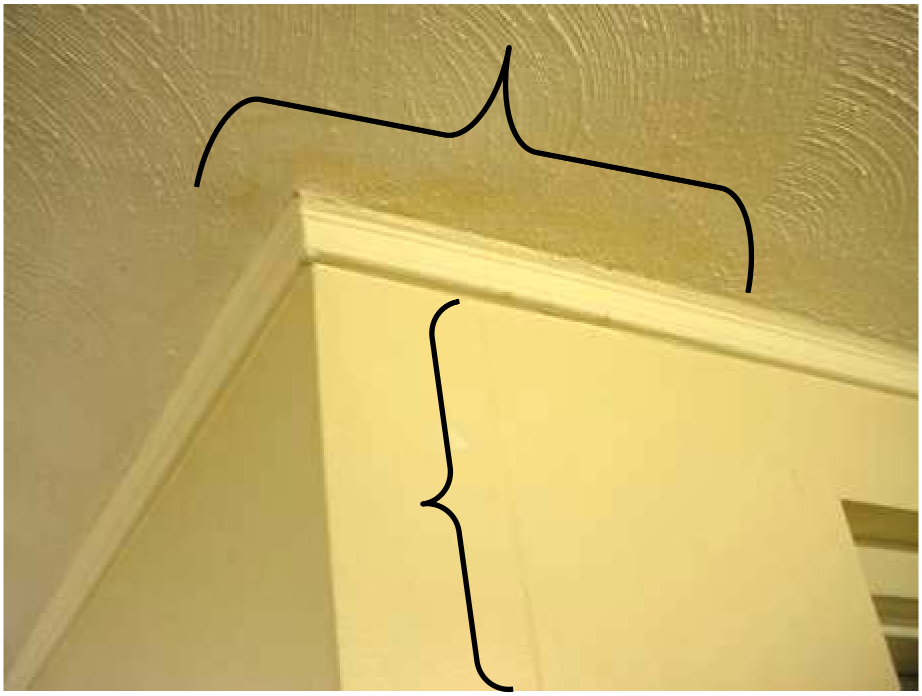
Picture 6

Damage to wood molding and cement due to chronic water exposure near rear exterior door

Picture 7

Damage to wood molding due to chronic water exposure near rear exterior door

Picture 8



Water damaged ceiling plaster and drip mark down wall indicating water penetration
(Note: This interior area corresponds directly to the damaged cornice in Picture 4)

Picture 9

Clinging plants on exterior wall

Picture 10

Close-up of Clinging plants on exterior wall,
Note trunk has worked its way between wooden trim and brick

Picture 11

Missing/damaged mortar around foundation stone

Picture 12

Missing/damaged mortar around exterior brick

Picture 13

Missing/damaged mortar around foundation stone

Picture 14

Spaces around exterior windows, probe inserted by BEH staff to illustrate depth

Picture 15

Close-up of spaces around exterior windows

Picture 16

Rotted/damaged wooden windowsills

Picture 17

Abandoned dryer exhaust vent

Picture 18

Wall breach in side stairwell partially sealed with wood

Picture 19

Severe damage to wall plaster and wooden stairs due to water penetration in side stairwell, Note piles of debris are corroded wood

Picture 20

Damaged base of basement door, Note drain in foreground

Picture 21

Close-up of clogged drain near basement doors

Picture 22

Leaking sink in basement

Picture 23

Cardboard boxes on cement floor of basement

Picture 24

Furnace in basement, missing its cover

Picture 25

Furnace in basement, missing its cover

Location: Milot House, Tewksbury Hospital Campus **Indoor Air Results**

Address: Tewksbury, Massachusetts **Table 1** **Date: 5/2/2007**

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp °(F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Background	410	1	58	65					Moderate rain in A.M., mostly cloudy-cool
Napolitano Office	593	1	68	50	2	Y	N	N	AC, window open
M7-A	661	2	72	38	3	Y	N	N	AC-dust/debris
Hallway (near rear exit)									Door-elevated moisture content Floor-dry/normal moisture content-warped due to moisture damage, Carpet- dry/normal moisture content
M10-C	588	2	76	31	1	Y	N	N	Window open
Kitchen	592	2	76	31	0	Y	N	Y	Local exhaust fan
Legal	736	2	76	31	0	Y	N	N	AC
2nd Floor Hallway									Water damaged ceiling plaster-cornice, drip stain on paint/wall
M2	700	1	77	32	1	Y	N	N	
M3	702	2	78	31	1	Y	N	N	

ppm = parts per million

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems		

Table 1 (continued)

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp °(F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
M4	671	1	77	30	0	Y	N	N	Window open, water damaged paper towels around AC

ppm = parts per million

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity:	70 - 78 °F 40 - 60%